GEOLOGY, ENERGY, AND MINERAL (GEM) RESOURCE ASSESSMENT OF THE TONGUE RIVER GEM RESOURCE AREA (GRA), MONTANA, INCLUDING THE ZOOK CREEK WILDERNESS STUDY AREA (MT-027-701), AND THE TONGUE RIVER BREAKS CONTIGUITY (MT-207-736)

PHASE I

Contract No. YA-553-CT2-1055

Prepared for:

U.S. Bureau of Land Management

Prepared by:

Tetra Tech, Inc.
Pasadena, California

September 1983

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EXECUTIVE SUMMARY

The U.S. Bureau of Land Management (BLM) has adopted a two-phase procedure for the integration of geologic, energy, and mineral (GEM) resources data concerning Wilderness Study Areas (WSAs). To facilitate this review, certain WSAs with similar geologic environments and mineral characteristics have been grouped together into larger GEM Resource Areas (GRAs). Using these guidelines, the Zook Creek and Tongue River Breaks Contiguity WSAs were grouped together into the larger Tongue River GRA. This report, which terminates the Phase I activities for the Tongue River GRA, is an evaluation and interpretation of existing data concerning the GEM resource potential in the WSAs.

The Tongue River GRA contains 2 WSAs: the Zook Creek WSA (MT-027-701), and the Tongue River Breaks Contiguity WSA (MT-027-736). Both WSAs are located in the BLM's Powder River Resource Area, Miles City District, Montana.

Both WSAs have a high favorability for the potential occurrence of coal (classified 4D); this classification is based upon abundant direct and indirect data supporting the occurrence of coal in the study area (Warren, 1959; Culbertson and Klett, 1976; Mapel et al., 1978A-E). Both WSAs have a high favorability for the potential occurrence of oil and gas (classified 4C); this classification is based upon direct evidence of numerous drill holes within the region producing hydrocarbons from stratigraphic and structural horizons that probably occur beneath the WSAs (Petroleum Information Corporation, 1982). The WSAs have a moderate favorability for the potential occurrence of clinker (classified 3D); this classification is based upon direct evidence from large scale geologic mapping identifying known clinker zones in the WSAs (Warren, 1959; Culbertson and Klett, 1976). Quantitatively minimal direct evidence exists to support a low favorability classification for the potential occurrence of other GEM resources in the study areas (classified 2C). This classification is based on the geologic environment and the inferred geologic processes that have been identified within the WSAs.

Additional geologic investigations would help supplement the GEM resource evaluation of the Tongue River GRA. An examination of well logs in the study area should be conducted to identify suitable stratigraphic and structural horizons for the accumulation of hydrocarbons and uranium. A considerable amount of geologic information exists which should be reviewed in depth by BLM personnel to gain additional insight into the potential occurrence of GEM resources in the study area.

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GEM RESOURCE AREA
TONGUE RIVER

1.0 INTRODUCTION

1.1 Purpose of Study

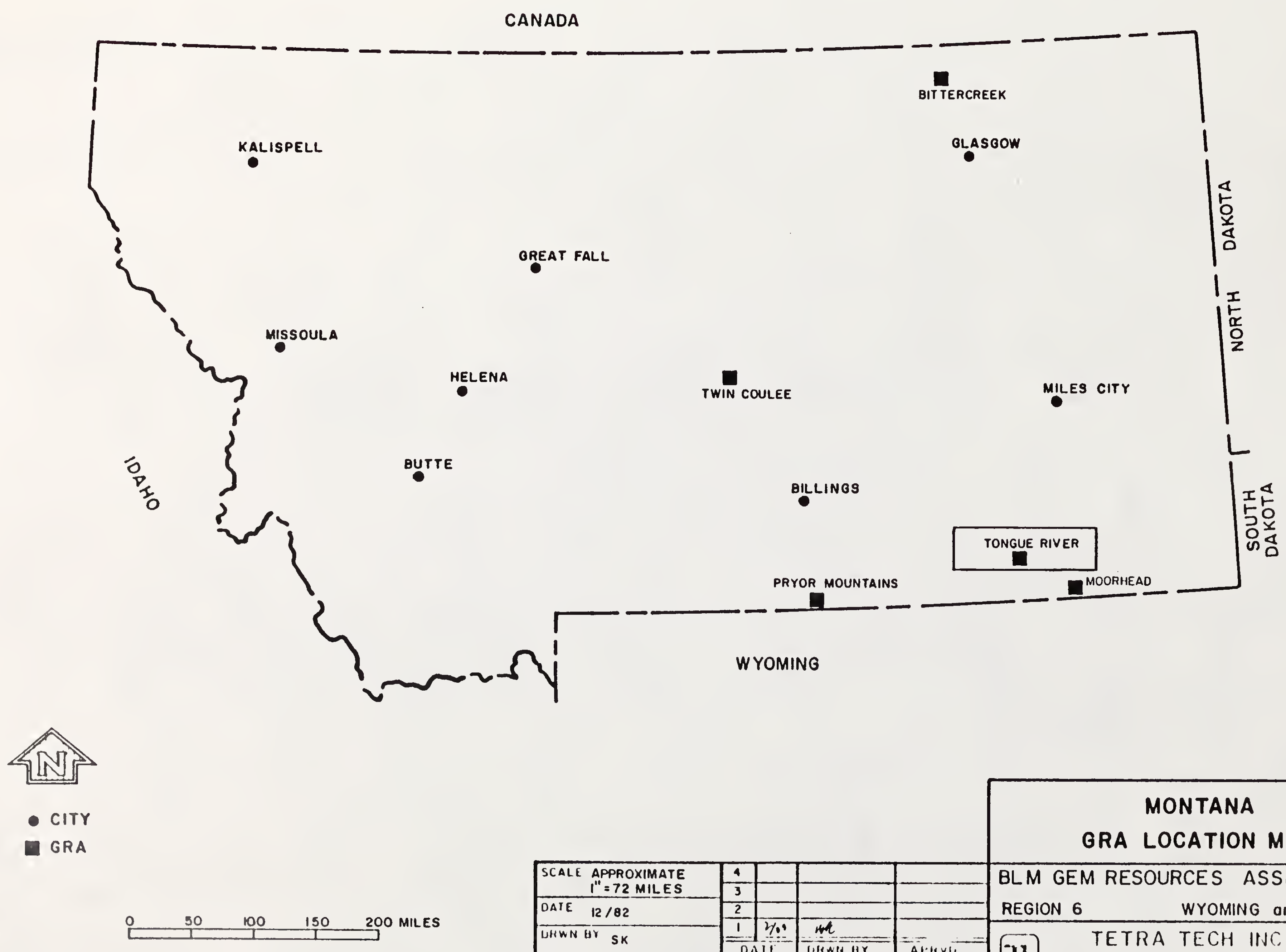
The U.S. Bureau of Land Management (BLM) has adopted a two-phase procedure for the integration of geologic, energy, and mineral (GEM) resources data concerning Wilderness Study Areas (WSAs). Phase I consists of a review and evaluation of existing data, resulting in an interpretation of the GEM resource potential in the WSAs. Phase II is designed to generate only the additional data required to support the GEM resource recommendations presented during Phase I. To facilitate this review, certain WSAs with similar geologic environments and mineral characteristics have been grouped together into larger GEM Resource Areas (GRAs). Using these guidelines, the Zook Creek and Tongue River Breaks Contiguity WSAs were grouped into the larger Tongue River GRA. This report, which terminates the Phase I activities for the Tongue River GRA, is an evaluation and interpretation of existing data concerning the GEM resource potential in the Zook Creek and Tongue River Breaks Contiguity WSAs.

The GEM resource evaluations for this study were performed by Tetra Tech, Inc. for the U.S. Bureau of Land Management, under Contract No. YA-553-CT2-1055. This study was completed in January, 1983.

1.2 Location and Access

This GEM report covers the area identified as the Tongue River GEM Resource Area (GRA); the geographic location of the study area is shown in Figure 1.1, "GRA Location Map."

The Tongue River GRA contains 2 WSAs: the Zook Creek WSA (MT-027-701), and the Tongue River Breaks Contiguity WSA (MT-027-736). The Zook Creek WSA consists of 8,440 acres and is located between 106° 32' and 106° 38' west longitude and 45° 18' and 45° 24' north latitude, in parts of Townships (T)



MONTANA
GRA LOCATION MAP

BLM GEM RESOURCES ASSESSMENT

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1.1

SCALE APPROXIMATE 1"=72 MILES
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5-6 South (S), Ranges (R) 41-42 East (E), Principal Prime Meridian (P.P.M.), Rosebud County, Montana. The Tongue River Breaks Contiguity WSA consists of 1,484 acres and is located between 106° 22' 30" and 106° 30' west longitude and 45° 20' and 45° 27' north latitude, in parts of Section 2, T 5 S, R 43 E, Section 31, T 5 S, R 43 E, and Section 5, T 6 S, R 43 E, P.P.M. Both WSAs fall within the BLM's Powder River Resource Area, Miles City District, Montana. Figure 1.2, "Topographic Map," illustrates the topography of the GRA, as well as the location of the WSAs within the GRA.

Access to the Tongue River Breaks Contiguity WSA is by an improved county road east of the Tongue River, 3 to 9 miles north of Birney, Montana. Further access is by an unimproved trail along Gate Creek and Black Eagle Creek. Primitive roads and unimproved tracks and trails intersect the Zook Creek WSA. Access to the primitive roads which interest the Zook Creek WSA is by ranch and county roads located a few miles northwest of Birney, Montana.

1.3 Basis for Report

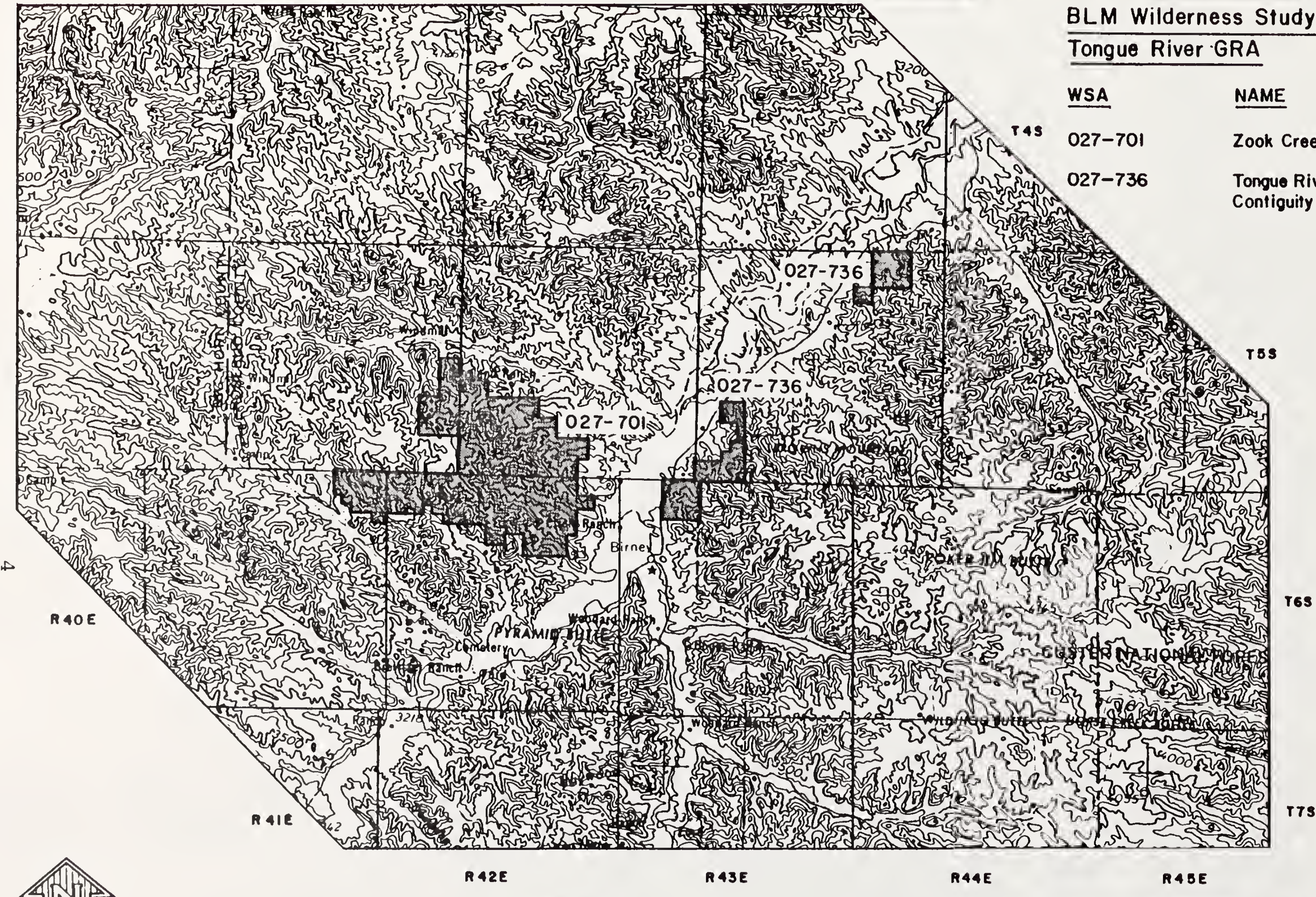
This report is based on an evaluation of existing data (both published and available unpublished data) collected from a variety of different sources. Some of the sources contacted during the preparation of this report include the U.S. Bureau of Land Management (BLM), the U.S. Geological Survey (USGS), the U.S. Bureau of Mines (USBM), the U.S. Department of Energy (DOE), the Wyoming Geological Survey, universities, and other sources listed in the references and selected bibliography section of this report.

The available literature was reviewed by a Project Team, assembled by the study contractor, comprised of authorities in the field of GEM resource evaluations. The members of the Project Team, and their associated technical disciplines, are identified below:

Mr. Charles S. Robinson	Metallic Minerals/Non-Metallic Minerals
Mr. Rollin E. Phipps	Oil and Gas
Mr. Andrew G. Alpha	Geothermal Resources
Mr. Stuart P. Hughes	Other Minerals
Mr. William A. Gallant	Other Minerals
Mr. Elmer M. Schell	Coal
Mr. John A. Hartley	Oil Shale/Paleontology

BLM Wilderness Study Areas Included in the Tongue River GRA

WSA	NAME	ACREAGE
027–701	Zook Creek	8,440
027–736	Tongue River Breaks Contiguity	1,484



(USGS, 1954; limited revision, 1963)

N

NOTE: Contours in 100 ft. Intervals

5 4 3 2 1 0 3 6 Miles

5 4 3 2 1 0 5 10 Kilometers

▨ Approximate Boundary of Wilderness Study Area

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REVISIONS

Tongue River GRA, Montana
TOPOGRAPHIC MAP

BLM GEM RESOURCES ASSESSMENT
REGION 6 WYOMING and MONTANA

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PASADENA, CALIFORNIA

FIGURE 1.2

2.0 GEOLOGY

2.1 General

The geology of the Zook Creek and Tongue River Breaks Contiguity WSAs is illustrated on the Montana State Geologic Map (Ross and Witkind, 1955), and geologic maps by Mapel and Martin (1978); Warren (1959); Matson and Blumer (1973); and Bergantino (1980). These maps, together with other available data listed in the references and selected bibliography section of this report, form the basis for certain conclusions regarding GEM resources in the study area.

The Zook Creek and Tongue River Breaks Contiguity WSAs are on the northern flank of the Powder River Basin. A thick sequence of sedimentary rocks underlies the WSAs and consists of rocks from Precambrian (> 600 million years before present [m.y.B.P.]) to Upper Cretaceous (70-100 m.y.B.P.) in age. The Tongue River Member of the Fort Union Formation of Tertiary age (< 70 m.y.B.P.) crops out in the WSAs. Thin surficial deposits overlie the bedrock units.

2.2 Physiography

The Tongue River GRA falls within the unglaciated section of the Great Plains physiographic province. The elevations range from approximately 3,000 feet in the Tongue River Breaks Contiguity WSA to 4,000 feet in the Zook Creek WSA.

The drainage in the area consists of small intermittent to perennial tributaries that intersect the WSAs and drain into the Tongue River. Rugged, steep badlands topography is common within the WSAs. The climate is similar to other areas of the Powder River Basin in that most precipitation occurs as rain during April, May, and June, with occassional high intensity scattered rain showers during other times of the year.

2.3 Geologic Units

The bedrock units that underlie the WSAs include rocks from Precambrian to Tertiary age. Many of the units that underlie the WSAs have been oil and gas producers in other parts of the Powder River Basin. Surficial deposits overlie a portion of the WSA and consist of alluvial and colluvial deposits. Figure 2.1, "Geologic Map," delineates the geologic formations that occur throughout the GRA. Figure 2.2, "Generalized Stratigraphic Column," is a generalized stratigraphic column which gives a brief description of all the stratigraphic units that underlie the Tongue River GRA.

2.3.1 Bedrock Units

The bedrock units that crop out within the GRA are interbedded yellowish to medium-gray massive sandstone and silty sandstone; medium gray shale; dusky brown to black carbonaceous shale; and persistent coal beds. These coal beds are part of the Tongue River Member of the Fort Union Formation of Paleocene age (60-70 m.y.B.P). The older rock formations are buried beneath the exposed younger rocks. Detailed examinations of drill hole logs will be required to describe the details of the underlying units.

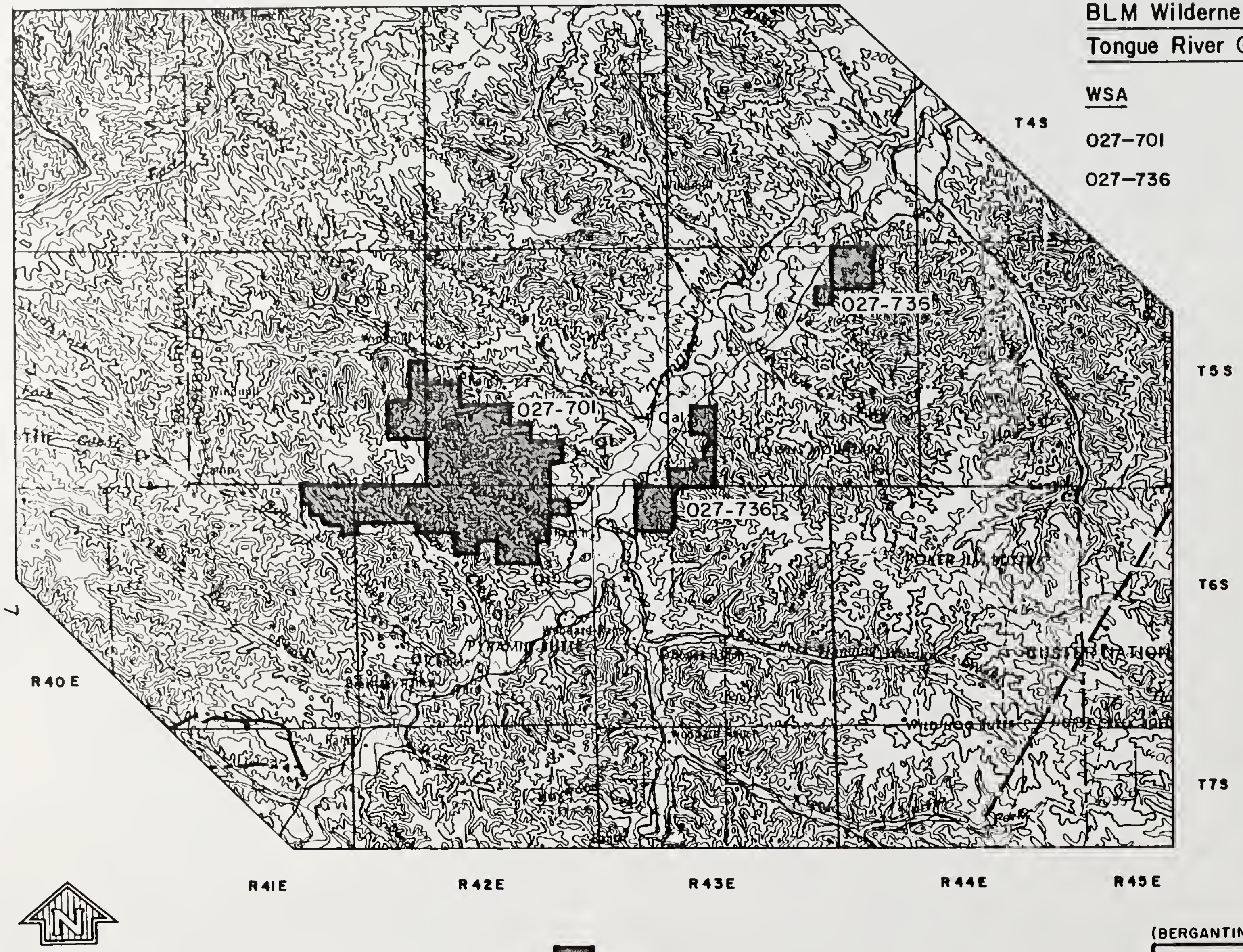
2.3.2 Surficial Deposits

Alluvial and colluvial deposits blanket the bedrock units within the WSAs. The alluvial deposits consist of alluvium developed along tributary drainages that intersect the WSAs. Slope wash deposits have developed on the bedrock slopes. Alluvial fan deposits are cone shaped deposits of debris formed at the mouths of tributary streams as they enter larger stream valleys.

Colluvial deposits consist of landslide deposits. Colluvium is formed from bedrock which has weathered in place, and clinker, which is formed from beds baked by burning coal. Clinker beds have not been mapped in detail throughout the area, but are expected to occur based upon known deposits in geologically similar areas.

BLM Wilderness Study Areas Included in the Tongue River GRA

WSA	NAME	ACREAGE
027–701	Zook Creek	8,440
027–736	Tongue River Breaks Contiguity	1,484



Approximate Boundary of Wilderness Study Area

(BERGANTINO, R.N., 1980)

Tongue River GRA, Montana

GEOLOGIC MAP

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PASADENA, CALIFORNIA

FIGURE 2.1

SCALE 1" = 4 MILES 1 : 250,000
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REVISIONS

SYSTEM	SERIES	SYMBOL	FORMATION	GENERAL LITHOLOGIC DESCRIPTION
QUATERNARY		Qal		Alluvium
TERTIARY	PALEO-CENE	Tfut	Fort Union-Tongue River	Massive sandstone and silty sandstone; shale and coal beds
		Tful	Fort Union (lower)	Sandstones, siltstones, shales and clays; shale and coal beds
CRETACEOUS	UPPER	Kuu	Bell Creek	Sandstone; shale and sandstone; conglomerate
			Fox Hills	Sandstone; conglomerate
			Bearpaw	Shale; shale and sandstone; conglomerate
			Judith River	Shale; shale and sandstone; sandstone interbedded with shale; conglomerate
			Claggett	Shale; shale and sandstone; conglomerate
			Eagle	Shale; sandstone; conglomerate
		Kul	Telegraph Creek	Shale
			Niobrara	Shale; shale interbedded with limestone
			Carliie	Shale; sandstone and shale
			Greenhorn	Shale; limestone
			Belle Fourche	Shale; sandstone
	LOWER	Kl	Mowry	Shale
			Thermopolis	Shale
		KJ	Dakota	Sandstone; sandstone and shale
			Fuson	Sandstone interbedded with shale; shale
			Lakota	Sandstone; sandstone interbedded with shale
JURASSIC	UPPER		Morrison	Shale and sandstone
			Swift	Sandstone; sandstone and shale; sandstone interbedded with limestone
			Sundance	Shale; sandstone; limestone
	LOWER		Piper	Shale; sandstone; shale and sandstone
TRIAS-SIC		TR	Chugwater	Limestone; shale and sandstone; anhydrite
			Dinwoody	Shale; sandstone; anhydrite
PERMIAN		PM	Phosphoria	Chert; limestone; shale and sandstone; sandstone and anhydrite
PENNSYL-VANIAN			Tensleep	Sandstone
			Amsden	Limestone and sandstone
			Tyler	Sandstone; sandstone and shale; anhydritic sandstone
MISSISSIPPIAN			Beath	Shale
			Otter	Anhydritic shale
			Kibbey	Sandstone
			Charles	Anhydritic limestone
			Mission Canyon	Limestone
			Lodgepole	Limestone
DEVONIAN		D€	Bakken	Sandstone; sandstone and shale
			Three Forks	Dolomite; limestone; sandstone
			Bird Bear	Limestone
			Duperow	Limestone; anhydrite
			Souris River	Dolomite; sandstone; anhydrite
SILURIAN			Interlake	Dolomite
ORDOVICIAN			Bighorn	Dolomite interbedded with shale
CAMBRIAN			Emerson	Limestone; shale; sandstone
PRECAMBRIAN		p€$_3$		Quartzite and metamorphic
		p€$_1$		Metamorphic and granite

Figure 2.2 Generalized Stratigraphic Column, Tongue River GRA. (American Association of Petroleum Geologists, 1972)

2.4 Structural Geology

A number of anticlines and synclines parallel the Tongue River on the east side, south of the WSAs (Petroleum Information Corporation, 1982). The subsurface structure of the study area is largely unknown because of the few drill holes in the area. The rocks dip gently to the southwest, into the far northern end of the Powder River Basin.

2.5 Engineering Geology

The engineering geology of the area has several significant characteristics. Landslides are common within the WSAs associated with the steep slopes developed in unstable bedrock and colluvium. Swelling soils are also commonly associated with the bentonitic shales that crop out in the Tongue River Member of the Fort Union Formation. Flash flooding may occur from time to time in the narrow tributary drainages in the area, as is typical of much of the Rocky Mountains area.

2.6 Paleontologic Resources

The Fort Union Formation has excellent possibilities for preservation of continental vertebrates, especially the Tongue River Member. Although no known fossils have been found in either the Zook Creek WSA or the Tongue River Breaks Contiguity WSA, a high potential exists for the occurrence of fossils in these areas.

2.7 Historical Geology

The geologic history of the Zook Creek and Tongue River Breaks Contiguity WSAs is that of the Powder River Basin. The basement Precambrian rocks in the area consist of metaigneous and metasedimentary rocks, the history of which is not well understood. At the end of Precambrian time and throughout the Paleozoic (225 m.y.B.P.) era, there were repeated advances and retreats of the sea. Marine deposits of sandstone, shale, and limestone were formed. At the end of the Paleozoic era, marine, marginal marine (evaporites), and terrestrial red-bed deposits were formed as the seas fluctuated back and forth over the area. During the deposition of the Paleozoic sediments, stratigraphic traps for hydrocarbons may have developed along facies changes, unconformities, and lithologic boundaries. Marine conditions returned in Jurassic (135-180 m.y.B.P.) time, only to retreat at the end of the Jurassic period. A major marine invasion started in early Cretaceous time and continued until the start of the Laramide orogeny near the end of the Cretaceous period. The Tertiary period was a period of repeated uplift, accompanied by folding, thrusting, and high-angle faulting, and the deposition of thick terrestrial sediments including coal in the intermountain basins. The Quaternary (2-3 m.y.B.P.) period was known for the oxidation of the coal beds, which in turn developed clinker horizons; during the Quaternary, the area was also eroded by streams.

3.0 ENERGY AND MINERAL RESOURCES

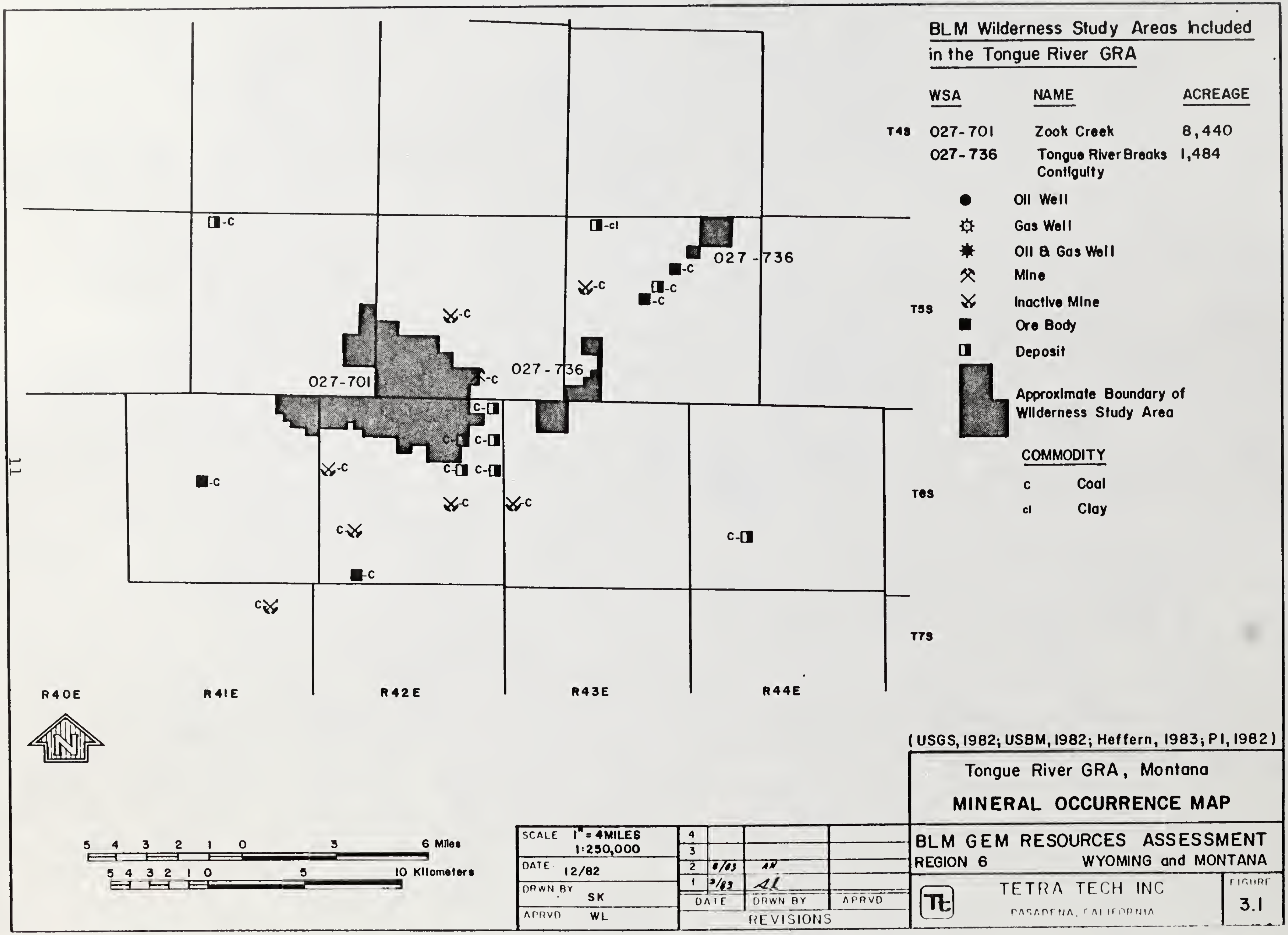
3.1 General

The Zook Creek and Tongue River Breaks Contiguity WSAs have known coal resources. The WSAs have the potential for oil, gas, and geothermal resources.

Figure 3.1, "Mineral Occurrence Map," illustrates the presence of any known past and present mine locations, or occurrences of mineral deposits and GEM resources within the GRA. Information for this figure came from the USGS' Computerized Resource Information Bank (CRIB), the USBM's Minerals Availability System (MILS), and the Petroleum Information Corporation (PI).

3.2 Known Resources

Known coal resources underlie both the Zook Creek and Tongue River Breaks Contiguity WSAs. In the Canyon Field, which contains the Zook Creek WSA, strippable coal reserves (> 5 feet thick, < 200 feet overburden) are calculated at 1,950 million tons; in the Birney Field, which contains the Tongue River Breaks Contiguity WSA, strippable reserves are calculated at 180 million tons (Bergantino et al., 1980). Table 3.1, "Coal Tonnage for the Zook Creek WSA," provides an estimate of the coal tonnage for the Zook Creek WSA.



BLM Wilderness Study Areas Included in the Tongue River GRA

WSA	NAME	ACREAGE
027-701	Zook Creek	8,440
027-736	Tongue River Breaks Contiguity	1,484

● Oil Well
☼ Gas Well
✸ Oil & Gas Well
⚒ Mine
Inactive Mine
■ Ore Body
◧ Deposit
▨ Approximate Boundary of Wilderness Study Area

COMMODITY

c Coal
cl Clay

(USGS, 1982; USBM, 1982; Heffern, 1983; PI, 1982)

Tongue River GRA, Montana

MINERAL OCCURRENCE MAP

BLM GEM RESOURCES ASSESSMENT
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TETRA TECH INC
PASADENA, CALIFORNIA

FIGURE
3.1

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Table 3.1
COAL TONNAGE FOR THE ZOOK CREEK WSA

Location	Tonnage x 10^6*
T 5 S, R 41 E	
E 1/2, Sec. 24	24.9
Sec. 25	46.1
T 5 S, R 42 E	
Sec. 19	16.7
28	5.7
29	27.2
30	39.7
31	36.7
32	41.1
33	21.5
34	2.5
T 5 S, R 43 E	
Sec. 30	6.7
31	14.8
T 6 S, R 41 E	
Sec. 1	1.1
2	13.8
3	33.1
T 6 S, R 41 E	
Sec. 4	26.3
5	37.6
6	8.3
8	6.8
9	19.1
10	31.3
11	14.4
T 6 S, R 43 E	
Sec. 5	14.9

(McKay, 1983)

*The tonnage figures are the inplace tons of coal times 10^6. These figures consider all the high and moderate potential coal. These figures are based on a stripping ratio of 15:1, or an overburden of 500 feet, with a bed thickness > 5 feet for moderate coal, and a stripping ratio of 6:1, or an overburden of 200 feet, with a bed thickness > 5 feet for high potential coal.

Tables 3.2 (a)(b) show the identified coal beds in the Birney Day School and Browns Mountain 7.5' Quadrangles (Colorado School of Mines Research Institute (CSMRI), 1979 A-E; Mapel and Martin, 1978). The named coal beds exposed in the Zook Creek area range from the Canyon to the Knoblock, with other local beds cropping out in between. In the northern part of the Tongue River Breaks Contiguity WSA, the Pawnee to Odell coal beds are exposed; in the southern part of the same WSA, the Upper Canyon to King coal beds are exposed.

Part of the coal beds at and near the surface burned and developed clinker along the edge of the outcrop. Clinker is derived from the baking of adjacent rocks by burning coal; clinker is abundant throughout the GRA (Culbertson and Klett, 1976; Culbertson, Mapel, and Klett, 1976; Warren, 1959; Mapel et al., 1978A-E). Clinker is widely used as a surface coarse material on unimproved graded roads; some might be used as aggregate.

3.3 Potential Resources

The WSAs have the potential for oil, gas, and geothermal resources. Stratigraphic traps may occur in the numerous sandstones of Cretaceous age and older rocks that underlie the WSAs. Structural traps associated with faulted and folded rocks are likely possibilities. Numerous dry holes have been drilled in the local area, and producing oil fields are within similar rocks in the region (PI, 1982). Geothermal sources of low temperature have been identified in the region (Sonderegger and Bergantino, 1981).

3.4 Land Status

Numerous oil and gas leases blanket the WSAs. This indicates interest in stratigraphic and structural traps in the underlying rocks within the region. Figure 3.2, "Claim and Lease Map," illustrates the locations of any oil and gas leases, patented claims, or unpatented claims in the Tongue River GRA. As shown, there are no patented claims in the WSAs.

Table 3.2(a)
COAL BEDS AND PARAMETERS, TONGUE RIVER GRA

Bed Name (interval between beds in feet)	Bed Thickness (in feet)	Overburden (in feet)	BTU	Rank
Canyon (70-160)	4-10	0-200	~8800	Subbituminous C
Lower Cook (35-40)	5-9	0-380	-	Subbituminous C
Otter	5-9	-	-	Subbituminous C
Wall (140-180)	30-40	0-500	~8970	Subbituminous B or C
Pawnee (100)	4-10	0-600	-	Subbituminous C
Cache (100-120)	<5	-	-	-
King (12-75)	2-9	0-1000	~9100	Subbituminous B
Knoblock (18-130)	10-24	0-1000	~8950	Subbituminous B
Nance (140)	4-10	100-1100	~8550	Subbituminous C
Flowers/Goodale (100-120)	6-24	180-1200	~8100	Subbituminous C
Terret	5-10	420-1400	~9000	Subbituminous C

(CSMRI, 1979 A-E)

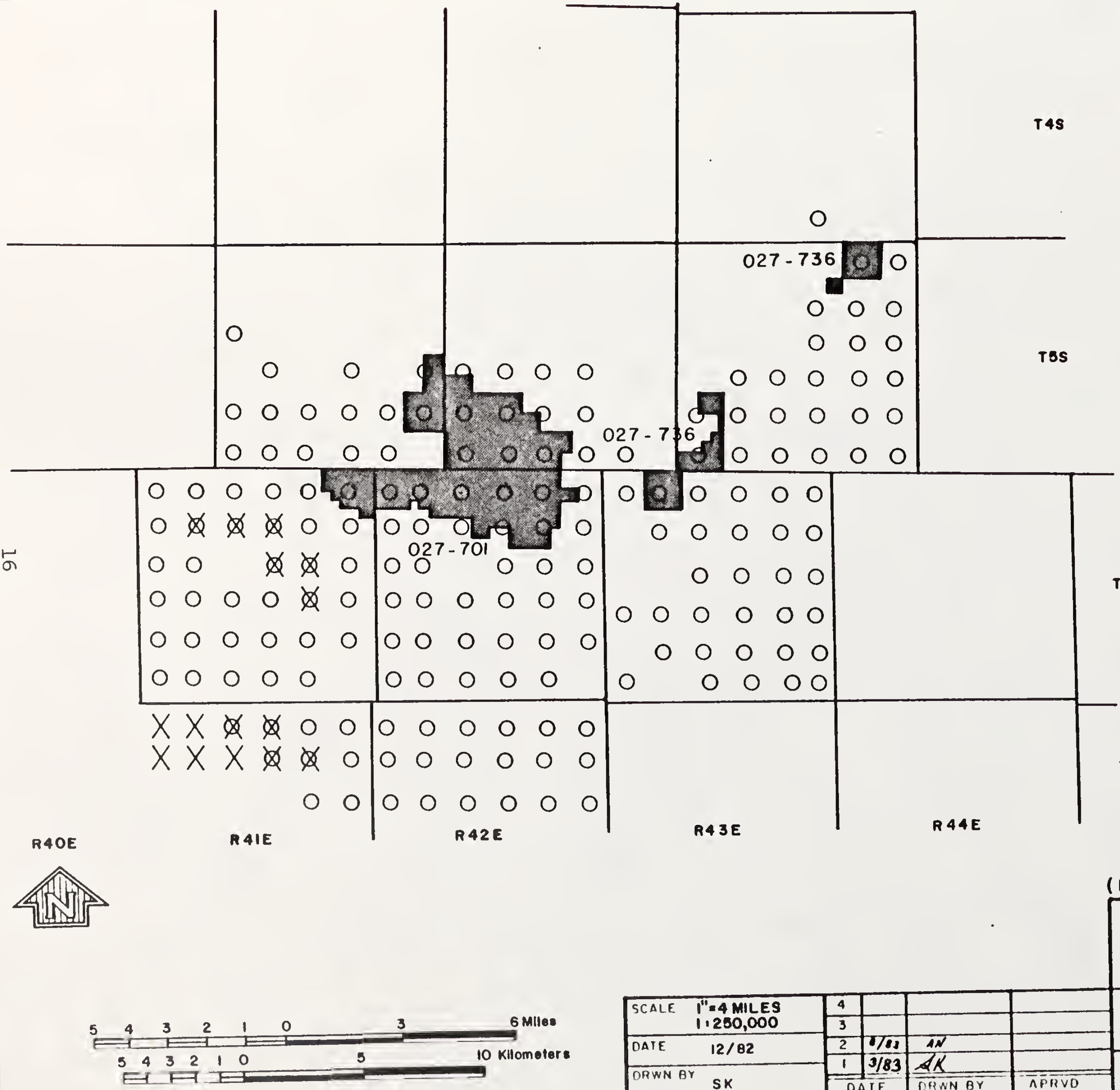
Table 3.2(b)
COAL BEDS AND PARAMETERS, TONGUE RIVER GRA

Bed Name (interval between beds in feet)	Bed Thickness (in feet)	Overburden (in feet)	BTU	Rank*
Anderson/Dietz (170)	34-54	0-clinker	7640-8375	-
Upper Canyon (40)	5-18	0-<300	7860-8800	-
Lower Canyon (40-110)	5-6	0-<300	-	-
Cook (30-80)	5-15	-	-	-
Upper Otter (5-30)	0-14	-	-	-
Lower Otter (40)	0-5	-	-	-
Wall (70-100)	0-7	-	7640-9565	-
Pawnee (100)	5-8	-	-	-
Poker Jim (40-60)	<5-10	-	-	-
Brewster/Arnold (30)	11+	<200	8700	-
Odell (160)	3-5	-	-	-
King (40)	5-7	-	9135	-
Knoblock (100-140)	16-18	-	8960	Subbituminous C
Nance (120)	10-12	-	-	-
Flowers/Goodale (220)	17-20	200-1000	7540-7570	-
Terret	5-10	500->1000	7630-7860	-

(Mapel and Martin, 1978)
*Rank of these coals is generally high subbituminous C to B.

BLM Wilderness Study Areas Included in the Tongue River GRA

WSA	NAME	ACREAGE
027-701	Zook Creek	8,440
027-736	Tongue River Breaks Contiguity	1,484



○ Oil & Gas Lease

△ Patented Claim

X Unpatented Claim

▨ Approximate Boundary of Wilderness Study Area

NOTE: Symbols illustrate those sections where claims or leases are present

(BLM, 1982)

Tongue River GRA, Montana

CLAIM MAP

BLM GEM RESOURCES ASSESSMENT
REGION 6 WYOMING and MONTANA

TETRA TECH INC
PASADENA, CALIFORNIA

FIGURE 3.2

SCALE	1"=4 MILES 1:250,000	4			
		3			
DATE	12/82	2	8/83	AN	
DRWN BY	SK	1	3/83	AK	
APRVD	WL		DATE	DRWN BY	APRVD
			REVISIONS		

3.5 Deposit Types

Coal occurs as a bedded deposit in the Tongue River Member of the Fort Union Formation of Paleocene age. Approximately 14 named coal beds, ranging in rank from subbituminous B to C, occur within the boundaries of the WSAs (Table 3.2 a and b). Clinker beds occur adjacent to the coal beds where the coal has burned due primarily to spontaneous combustion; this combustion has baked the adjacent rocks. The clinker will occur as far into the outcrop as oxygen was available for combustion of the coal (Culbertson and Klett, 1976; Culbertson, Mapel, and Klett, 1976; Warren, 1959; Mapel et al., 1978A-E).

3.6 Resource Economics

3.6.1 Industrial Minerals

Clinker is abundant within the WSAs. Due to its abundance throughout the region, the economic potential of the material is questionable except for local uses in road surfacing.

3.6.2 Coal

There is significant local interest in developing the strippable coal within the region. Markets for this material already exist; sales of the material are dependent on competitive pricing.

The coal industry is closely associated with the generally depressed economic conditions of the nation. Major users of coal are electric generators and there is a trend to move from oil and uranium to coal generator plants. However, the slow down in U.S. industrial output has reduced electrical energy needs, thus reducing even these small gains in coal use. The use of coal for synfuels has been seriously reduced because of the federal government's declining support for synfuel projects. As the economy recovers, the demand for energy and, therefore, coal should increase, thus encouraging additional coal production efforts.

3.6.3 Oil and Gas

Markets for the potential oil and gas resources of the area already exist. Exploration for oil and gas has levelled off after a peak of activity in January, 1982; this decline in exploration has been caused by the reduction of oil prices due to lower demand. Exploration for these resources should accelerate with increased demand, the reduction of existing inventories, and an increase in price.

4.0 LAND CLASSIFICATION FOR GEM RESOURCE POTENTIAL

4.1 General

The Zook Creek and Tongue River Breaks Contiguity WSAs are considered to have a high favorability for coal resources; this rating is based on abundant direct and indirect evidence. The WSAs are considered to have a high favorability for oil and gas resources; this rating is based on direct but quantitatively minimal evidence. The WSAs are considered to have a moderate favorability for clinker resources; this rating is based on abundant direct and indirect evidence. Finally, the WSAs are considered to have low favorability for geothermal resources; this rating is based on direct but quantitatively minimal data. The geologic environment and inferred geologic processes identified in the WSAs are not favorable for the occurrence of other GEM resources.

In order to better evaluate the occurrence or potential occurrence of resources in the GRA, a 2-part resource classification scheme has been adopted. Each resource or potential resource within the GRA will receive an alphanumeric designation. The number designation will range from 1 to 4, and will indicate the favorability of the geologic environment, geologic processes, and mineral occurrences for the presence of a particular resource. The letter designation will range from A to D, and will indicate the level of confidence to be associated with the numerical designation. Figure 4.1, "Land Classification Map," illustrates the areas of potential GEM resources with their assigned classifications for the WSAs within the Tongue River GRA. Figure 4.2, "Resource Classification Scheme," provides a detailed description of the number and letter designations used in the resource classification scheme.

4.2 Industrial Minerals

Both the Zook Creek and Tongue River Breaks Contiguity WSAs are considered to have a moderate favorability based on abundant direct evidence for the occurrence of clinker (classified 3D); this classification is based upon the occurrence of clinker in favorable geologic environments adjacent to burned coal beds, and available direct evidence from geologic mapping within the WSAs (Culbertson and Klett, 1976; Warren, 1959). The abundance of clinker in the GRA indicates that it is probably only suitable for local use.

4.3 Energy Resources

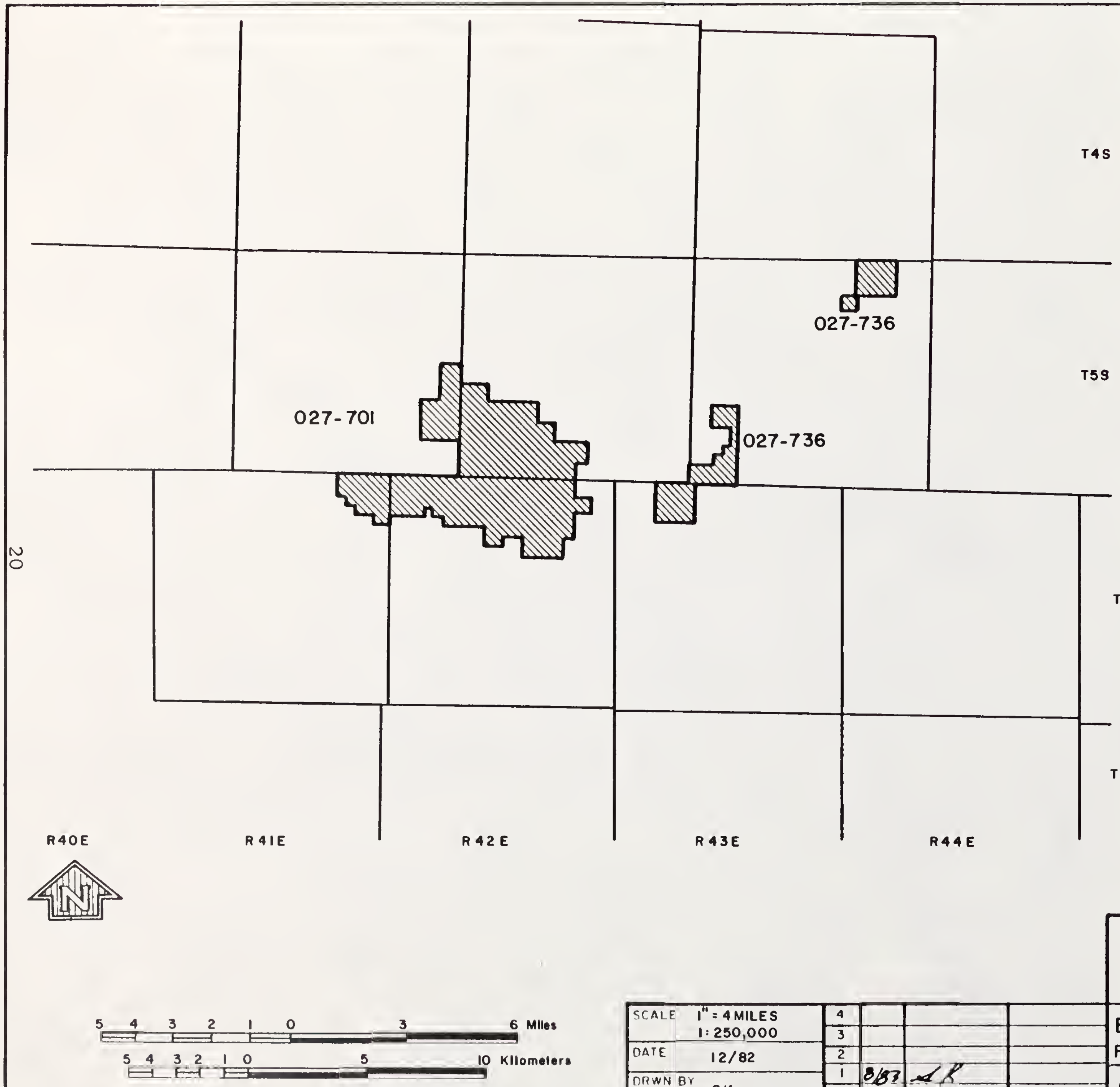
Potential energy resources identified within the WSAs include coal, geothermal, and oil and gas.

4.3.1 Coal

Both the Zook Creek and Tongue River Breaks Contiguity WSAs are considered to have a high favorability based on abundant direct evidence for the occurrence of coal (classified 4D); this classification is based upon the occurrence of significant coal beds cropping out in the region, and available direct evidence from geologic mapping within the WSAs (Mapel and Martin, 1978; CSMRI, 1979A-E; Warren, 1959).

4.3.2 Oil and Gas

Both WSAs are considered to have a high favorability based on direct, but quantitively minimal evidence for the potential occurrence of oil and gas resources (classified 4C); this classification is based upon the production of



BLM Wilderness Study Areas Included in the Tongue River GRA

WSA	NAME	ACREAGE
027-701	Zook Creek	8,440
027-736	Tongue River Breaks Contiguity	1,484

SYMBOL	GEM RESOURCE	CLASSIFICATION
▨	Coal	4D
	Oil & Gas	4C
	Geothermal	2C
	Clinker	3D
	Other GEM Resources	2C
☐	Approximate Boundary of Wilderness Study Area	

SCALE	1" = 4 MILES 1:250,000	4			
DATE	12/82	3			
DRWN BY	SK	2			
APRVD	WL	1	8/83		
			DATE	DRWN BY	APRVD
		REVISIONS			

Tongue River GRA, Montana

LAND CLASSIFICATION MAP

BLM GEM RESOURCES ASSESSMENT
REGION 6 WYOMING and MONTANA

TETRA TECH INC
PASADENA, CALIFORNIA

FIGURE
4.1

Numerical Classification Scheme

1) The geologic environment and the inferred geologic processes do not indicate favorability for accumulation of mineral resources.

2) The geologic environment and the inferred geologic processes indicate low favorability for accumulation of mineral resources.

3) The geologic environment, the inferred geologic processes, and the reported mineral occurrences indicate moderate favorability for accumulation of mineral resources.

4) The geologic environment, the inferred geologic processes, the reported mineral occurrences, and the known mines or deposits indicate high favorability for accumulation of mineral resources.

Letter Classification Scheme (Level of Confidence)

A) The available data are either insufficient and/or cannot be considered as direct evidence to support or refute the possible existence of mineral resources within the respective area.

B) The available data provide indirect evidence to support or refute the possible existence of mineral resources.

C) The available data provide direct evidence, but are quantitatively minimal to support or refute the possible existence of mineral resources.

D) The available data provide abundant direct and indirect evidence to support or refute the possible existence of mineral resources.

Figure 4.2 Resource Classification Scheme

oil and gas from stratigraphic and structural traps in adjacent areas that are similar to those that may occur beneath the WSAs. This classification is also based on available direct evidence from exploration within the area (PI, 1982).

4.3.3 Geothermal Resources

Both WSAs are considered to have a low favorability based on direct, but quantitively minimal evidence for the potential occurrence of geothermal resources (classified 2C); this classification is based upon the occurrence of potentially favorable geothermal systems at depths in adjacent areas, development of water supplies for coal development, and geothermal heat pump applications for space heating and industrial applications (Sonderegger and Bergantino, 1981).

4.4 Other GEM Resources

Quantitatively minimal direct evidence exists to support a low favorability classification for the potential occurrence of other GEM resources in the study area (classified 2C). This classification is based on the geologic environment and inferred geologic processes that have been identified within the WSAs.

5.0 RECOMMENDATIONS FOR FURTHER WORK

5.1 Work Recommended to Complete Data Base

A number of investigations could be implemented to generate additional data to suplement the conclusions of this Phase I report for the Tongue River GRA. An in-depth study of potential reservoir rocks that underlie the WSAs should be conducted by evaluating oil well logs in the area; this evaluation would help define the oil and gas potential of the region.

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